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A minimal representation of turbulence in plane Couette flow

DENNICE F. GAYME, VAUGHAN THOMAS, Johns Hopkins University, BRIAN FARRELL, Harvard University, PETROS IOANNOU, University of Athens — We describe a stochastic structural stability theory (S3T) based model of fully developed turbulence in plane Couette flow. This model is obtained by partitioning Navier Stokes into a nonlinear equation governing the evolution of the streamwise averaged mean flow and a linearized equation for the covariance of streamwise varying perturbations. When coupled, these equations explicitly model the dynamics of a second order approximation of the probability distribution of the turbulence. We investigate this system using a computationally tractable Restricted Nonlinear (RNL) model that represents the dynamics of a single member of the infinite ensemble of the S3T system. The RNL system has been shown to capture the dynamics of roll/streak structures and to support self-sustaining turbulence. Our results demonstrate that this self-sustaining state naturally collapses to a minimal realization of turbulence that retains only the essential set of streamwise varying perturbations. Comparisons to DNS data show that this minimal representation captures the salient features of fully developed turbulence and that the wavelengths involved in this behavior are independent of the number of streamwise modes used or the channel length.

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